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Pricing and issuance dependencies in structured financial product portfolios

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Abstract

We exploit a unique sample of structured financial products (SFPs) to analyze pricing and issuance dependencies among different types of such market-linked investment vehicles. Our study provides evidence of cross-pricing between products with complementary payoff profiles. Such dependencies may be explained by issuers' efforts to generate order flow for products that supplement their current SFP risk exposure. Additionally, we observe issuance patterns in line with the argument that issuers exploit the complementarity payout profiles when bringing SFPs to market. Our study emphasizes cross-pricing from a perspective not previously considered in the literature.

KEYWORDS

cross-pricing, discount certificate, hedging, issuance decisions, put warrants, structured financial products

JEL CLASSIFICATION

G12, G13, G14, G24

1 | INTRODUCTION

Cross-selling (Laux & Walz, 2009; S. Li, Sun, & Wilcox, 2005; X. Li, Gu, & Liu, 2013; Santikian, 2014; Zhao, Matthews, & Murinde, 2013) and coordinated pricing for multiple products or services (Bajwa, Sox, & Ishfaq, 2016; Calomiris & Pornrojnangkool, 2009; Duvvuri, Ansari, & Gupta, 2007; Lepetit, Nys, Rous, & Tarazi, 2008; Odegaard & Wilson, 2016) have a long tradition. It usually considers pricing decisions of suppliers in an effort to sell multiple products to the same customer or investor (Calomiris & Pornrojnangkool, 2009). Dependencies between prices of different products or services may therefore arise from the effort to sell to the same customer. We argue that cross-selling and coordinated pricing could also be relevant when products are sold to different customers. Suppliers may implement cross-pricing in an effort to exploit advantages regarding the risk-return profile of their product range. Thus, when implementing cross-pricing, the supplier of the products is not primarily concerned with customer retention but instead benefits from a risk exposure perspective. Such cross-pricing considerations from a risk perspective are relevant in various settings. For instance, acquirers may bid more for those targets that enhance cash flows due to earning diversification (Benston, Hunter, & Wall, 1995). We study cross-pricing using a unique data set of various products from financial institutions, which allow us to study these dependencies arising from a risk management perspective within rather than between firms.

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Investment and universal banks issue so-called structured financial products (SFPs), defined here as products derived from other securities traded on regular segments of financial markets.[1] These SFPs offer prepackaged investment strategies based on derivative products to retail investors, who cannot, because of market bottlenecks, construct the payoff structure of SFPs from components traded in regular financial market segments.[2] Several types of SFPs are available. Put and call warrants, for instance, are very simple products that have the same payoff profiles as put and call options; the latter but not the former are traded in regular segments of financial markets with margin calls. More complex products are, for instance, discount certificates: Investors participate in the value development of an underlying security up to a prespecified value, which is called the *CAP*. In exchange for this limited up-side potential, they buy the certificate at a *discount* relative to the current market value of the underlying security.

The market for SFPs is confined to a small number of large financial institutions, which simultaneously act as market makers (Baule, 2011). Selling SFPs, which are also known as a market-linked investment, exposes the financial institutions to market risk. Issuers manage the market risk of their sales in various ways: First, the financial institutions oftentimes create and set up hedging programs through their derivative trading desks. Although SFPs are written on an underlying security for which different derivative contracts are traded in the market, this type of hedging program can be conveniently implemented with these derivatives; second, issuers of SFPs commonly use delta-hedging programs when writing these contracts, similar to what market makers do in option markets. Third, these financial institutions may choose not to hedge their market risk exposure for certain products (i.e., out-of-the-money [OTM] put options in a bullish period).

In addition to these hedging strategies, and this is the core contribution of our paper, issuers of SFPs may use cross-pricing and cross-issuance to manage their market risk. We argue that the choice of pricing and product range can serve as valuable risk management methods to complement conventional hedging.[3] In more detail, some SFPs yield positive payoffs during market downturns, whereas other SFPs yield positive payoffs during bull markets. Thus, a well-grounded combination of various types of SFPs creates a riskless payoff. Moreover, SFPs are particularly suitable for this type of risk management strategy, as the expansion of the product range is simple and issuance costs for all products are similarly small. Although we are particularly interested in the potential risk management dimension of the dependencies, we also have to rule out other reasons that motivate the existence of pricing and issuance dependencies in SFP portfolios. These are (a) the values for all products depend on a market index and this may drive cross-pricing and cross-issuance patterns; (b) retail investors may prefer products with particular characteristics such that cross-pricing and cross-issuance patterns may be created by investors' preferences and their demand behavior.

We study pricing and issuance dependencies between various products belonging to the same SFP portfolio. We consider all SFPs outstanding in the German market between January 2008 and June 2010 with the German performance index (DAX) as the underlying security.[4] We selected this time period because only put and call warrants and discount certificates were issued in substantial number. Therefore, our study design has to address only a limited number of complementary product combinations. Some product combinations yield very simple payoff structures. For instance, an issuer that offers a large number of OTM put warrants faces high payouts during market downturns. This issuer can reduce the volatility of its payouts by also selling discount certificates with *CAP*'s similar to the strikes of the put warrants. Similarly, an issuer that offers discount certificates can reduce the volatility of its payouts by also offering put warrants with strikes similar to the *CAP*'s of the discount certificates. In both cases, the risk exposure of the resulting portfolio is reduced. All other product type combinations do not yield a risk reduction, which is why the put–discount combination is our working horse.

To identify cross-product pricing dependencies, we start with a difference-in-differences approach, with which we determine whether issuers change product prices when they intensely sell products with complementary payout profiles. Recent literature already suggests that issuers change their pricing behavior when retail investors intensely purchase products (Baule, 2011), but it does not consider pricing implications initiated by the demand for

[1]We provide a brief introduction to SFPs in Appendix A.

[2]In addition to rational motives for purchasing these products, which are known to be sold at considerable premiums over their theoretical values (TVs; Carlin, 2009; Henderson & Pearson, 2011), the behavioral literature brings forth additional motivations for investors to purchase SFPs. For example, Das and Statman (2013) argue that SFPs have substantial roles in behavioral portfolios that are composed of mental account subportfolios. Similarly, using prospect theory, Hens and Rieger (2014) show that investors can obtain a sizable utility gain from investing in SFPs (see also, e.g., Breuer & Perst, 2007; Vandenbroucke, 2015). Moreover, Bernard, Boyle, and Gornall (2009) argue that SFPs in the United States often contain unreasonably optimistic hypothetical scenarios in their prospectuses, which may contribute to their popularity with uninformed investors. In a similar direction, Döbeli and Vanini (2010) analyze what types of SFP product descriptions motivate investors to purchase SFPs.

[3]Former employees of a financial institution engaging in the market for SFPs confirmed that issuers indeed rely on the described strategy to complement their risk management efforts.

[4]Issuers also offer other SFPs that are not listed on an official regulated market for SFPs (see Célérier & Vallée, 2016), which we do not consider in our analysis.

another product type. For example, an issuer may offer a product that is complementary to its risk exposure at a discount to attract order flow or may use part of its diversification gains to offer (some) products at more favorable prices than its competitors. In other words, issuers may engage in cross-pricing. Dependencies in SFP portfolios might influence the pricing of these products and give issuers a comparative advantage over other issuers when pricing these products. We study price changes of put warrants when discount certificates are sold intensely and price changes of discount certificates when put warrants are sold intensely. Thus, our identification rests on the basic argument that under particular circumstances, for instance, when issuers have sold a substantial number of discount certificates, it is more worthwhile to offer puts with complementary payoff profiles at attractive prices to retail investors. Consistent with risk management considerations, we find that prices of matching products are reduced when products with complementary payout profiles are sold. We rule out that retail investors' preferences cause the price drop by controlling for the demand for put warrants (discount certificates) when investigating put prices (discount prices).

We also study pricing dependencies using a portfolio perspective. Following this approach, we study portfolios of one product type with different strikes (*CAP*'s) and times to maturity and take into account that SFPs do not exhibit symmetric payoff profiles. Instead, payoff profiles are characterized by points of discontinuity and nonlinearity, and, for the most part, exhibit nonzero skewness and nonnormal kurtosis. The recent literature finds that investors are concerned about higher moments when making investment decisions (Amaya, Christoffersen, Jacobs, & Vasquez, 2015; Chabi-Yo, 2012; Noussair, Trautmann, & van de Kuilen, 2014). In the context of SFPs, Bergstresser (2008) states that types of higher-order risk exposure have been identified as a source of concern for financial institutions with significant business. Higher moments of SFP portfolios are subject to the distance between the strike and the value of the underlying security of all outstanding products, and they can be influenced by strategically issuing new SFPs. Therefore, we expect issuers to consider their portfolio's probability distribution of future payouts. If issuers strategically exploit dependencies between different types of SFPs, they may take higher moments of their SFP portfolio into account. We investigate moments of the put portfolio and relate these to the margins of discount certificates. We do so to determine whether issuers consider asymmetry and fat tails when pricing SFPs. For instance, one might expect to observe a relationship between the manifestation of higher-order moments of the put portfolio and the pricing of complementary products. In line with our argument that issuers of SFPs exploit complementary risk profiles of SFPs to their advantage, our study provides evidence that the margins of discount certificates correlate with the risk exposure of the issuers' put warrant portfolio. This result is unlikely driven by correlated demand for put warrants and discount certificates with similar features as the trading volume between complementary products with similar features is virtually uncorrelated.

This paper also analyzes issuance patterns with regard to the issuers' choice of the product features they bring to market. Contemplating the strikes of new SFPs, issuers could most easily follow a uniform distribution of strikes around the current value of the underlying security when bringing new products to market. Thus, issuers could center issuance patterns around the current value of the underlying and symmetrically issue in-the-money (ITM) and OTM products. Second, issuers could follow the demand of investors. That is, issuers could issue more ITM than OTM discount certificates and more OTM than ITM put warrants (Bollen & Whaley, 2004; Gârleanu, Pedersen, & Poteshman, 2009) rather than offering a symmetric portfolio. Third, issuers could take other facets into account when issuing new products. For example, as argued by Bergstresser (2008), issuers may consider the risk exposure of their SFP portfolio and may prefer to issue products that possess underlying risks that are easier for them to hedge. Building on this argument, we show that issuers do not simply issue SFPs symmetrically. Moreover, we provide evidence that issuance patterns are not always demand driven but appear to be influenced by a different motivation. We check whether the issuance probability of put warrants that match a discount certificate increases when retail investors have begun to purchase the respective matching discount certificate. By doing so, issuers may aim at exploiting the complementary payout structures of these products. We find that the issuance probability of a put warrant increases in the demand for the complementary discount certificate. Our evidence suggests risk management considerations as a credible justification for this pattern.

In summary, the results from our study on the pricing and issuance patterns suggest that issuers of these products indeed sometimes price their products in an effort to exploit these complementary payout profiles and issue complementary products. Our results indicate that issuers utilize cross-pricing and cross-selling to manage their risk exposure in addition to the aforementioned traditional risk management strategies. Thus, we provide evidence that the choice of product range may be utilized as a risk management method and document cross-pricing and cross-selling in the context of risk management.

2 | PRICING DEPENDENCIES

2.1 | Complementary products

Issuers' risk-return profile of their SFP portfolios depends on which product types they combine. Perhaps most prominently, issuers may bundle put warrants and discount certificates. If the time to maturity of both products is similar, and the strike of the put warrant is similar to the *CAP* of the certificate, the resulting payoff is (almost) deterministic. Such a combination would save delta-hedging costs of the issuer. Issuers can also generate a deterministic payoff profile by selling a discount certificate and a matching call with similar time to maturity and a strike similar to the *CAP* of the discount certificate while simultaneously purchasing the underlying. However, pursuing this strategy results in large up-front payments by the issuer (for purchasing the underlying), whereas the *put–discount strategy* does not require any up-front payments. In contrast, this strategy results in a positive cash inflow from the warrant and discount premiums. For this reason, we investigate put–discount matching pairs.

Our study design addresses dependencies among single products and is based on the idea that the complementarity of payouts among different products should be more relevant in certain circumstances than in others. One such circumstance may be intense demand from retail investors: Suppose issuers have sold many discount certificates. If matching put warrants are (already) offered in the market, issuers have an incentive to reduce the prices of these matching put warrants to attract order flow and create an in-house hedge for the discount certificates sold, or alternatively, issuers are able to reduce the prices of put warrants, as they are hedged against large payouts during market downturns by means of the discount certificate. Hence, they might reduce the prices of the matching put warrants, as their inventory risk is reduced if matched discount certificates and put warrants are sold. In a similar context, Muravyev (2016) shows that the inventory risk faced by market makers has a significant impact on option prices. Note that, in this context, two courses of action are possible: First, issuers' primary business may be in the put warrant market, whereas the market for discount certificates is used for hedging. Second, issuers may primarily operate on the discount certificate market and complementarily engage in the put warrant market. Of course, issuers could also equally attend to both markets and still benefit from the complementary risk profiles of the products. Our first hypothesis reads as follows:

H1: *A large demand for the complementary product is associated with lower prices of the matching product.*

2.2 | Data and variable definition

We consider SFPs outstanding in the Certificate Stock Exchange between January 2008 and June 2010 with the DAX performance index as the underlying. ARIVA.DE provided all information on issuing activities and quoted prices of the products. In Table 1, we depict the number of put and call warrants and discount and bonus certificates for those issuers with more than 20 products outstanding. The category *OTHERS* contains index, sprint, guarantee, express, twin-win, and outperformance certificates. The table shows that, in our sample period, not all products were equally relevant in terms of their numbers. Rather, discount certificates dominate the sample. Moreover, put warrants play an important role, which might be because they offer a complementary payoff profile to discount certificates. Furthermore, issuers differ in what types of products they bring to market. For instance, UBS issued few warrants, while it had a very high number of discount certificates outstanding.

We identify matched product pairs by comparing the features of certificates with the features of warrants. To be classified as matched put–discount pair, we require that (a) both the put warrant and discount certificate are from the same issuer, (b) both products are outstanding but are not necessarily issued at the same point in time (the warrant might have been issued earlier or later than the discount certificate), (c) the warrant's strike equals the certificate's *CAP*, and (d) the maturity dates of the two are allowed to differ by no more than 5 trading days. In Table 1, we also present the number of matched put–discount pairs and depict whether the put is issued before or after the respective discount certificate. For reasons of comprehensiveness, we also show the number of matched call–discount pairs. It is clear that most issuers more frequently bring put warrants to the market after they have issued discount certificates rather than issuing put warrants before they have issued discount certificates.

We use the following product-specific control variables, all of which have been used in the literature. Central to our analysis of cross-product pricing and issuance is retail investors' demand. We use trading data from the European

TABLE 1 Overview of products and issuers

						Warrant first		Discount first	
Issuer	**Put**	**Call**	**Discount**	**Bonus**	**Other**	**Put**	**Call**	**Put**	**Call**
BHF Bank	0	0	97	8	9				
BNP Paribas	1,267	1,497	1,913	750	77	292	391	540	454
Bank of America	0	0	189	0	0				
Barclays Bank	0	0	108	1	3				
Citigroup	2,982	3,312	2,541	175	190	358	456	663	622
Commerzbank	3,238	3,587	3,507	294	172	236	523	1,180	961
DZ Bank	354	381	1,018	0	12	1	12	35	25
Deutsche Bank	6,233	6,479	2,803	20	31	193	213	476	447
Dresdner Bank	1,294	1,167	1,948	0	12	17	37	180	121
Goldman Sachs	4,054	4,212	3,009	1,761	3	404	568	916	578
HSBC	1,281	1,381	708	1	5	246	162	241	122
LBBW	5	6	272	1	8				
Morgan Stanley	9	11	512	1	2	0	2	4	3
Sal. Oppenheim	57	88	575	110	5	0	2	8	0
Société Générale	355	436	649	642	7	92	100	34	16
RBS	4	3	615	92	4	0	3	3	0
UBS	32	32	4,693	28	6	4	4	14	14
Vontobel	1,399	1,389	612	0	1	128	130	225	225
WGZ BANK	0	1	159	0	0				
WestLB	0	0	34	0	3				
OTHER	82	143	41	15	26				
Total	22,646	24,125	26,003	3,899	576	1,971	2,603	4,519	3,588

Note. This table depicts the number of structured financial products (SFPs) outstanding between January 2008 and June 2010. The product category *OTHER* contains index, sprint, guarantee, express, twin-win, and outperformance certificates. *OTHER* issuers are Bayerische Landesbank, Deka Bank, HypoVereinsbank, ING Bank, Landesbank Berlin, Lang and Schwarz, Norddeutsche Landesbank, Raiffeisen Centrobank, Oesterreichische Volksbanken, Bear Stearns International, HSH Nordbank, and JP Morgan.

Warrant Exchange and Certificate Stock Exchange provided by the Karlsruher Kapitalmarktdatenbank. Retail investors can buy and sell SFPs on secondary markets and over the counter (OTC). According to practitioners, a substantial number of SFPs are sold OTC. Most research on SFP demand uses data from secondary markets to identify demand effects (e.g., Baule, 2011). Only one study uses both transactions on secondary markets and OTC transactions (Entrop, Fischer, McKenzie, Wilkens, & Winkler, 2016). Although we lack OTC data, we use the number of products traded to capture retail investors' demand, *SHARES*. *MONEY* ($MONEY^{PUT}$) denotes the moneyness of the discount certificates (put warrants) defined as $MONEY_{it} = (CAP_i - S_t)/S_t$ ($MONEY_{it}^{PUT} = (Strike_i - S_t)/S_t$), where S_t denotes the value of the DAX index at time t, CAP_i denotes the level up to which the investor participates in the development of the underlying of certificate i, and *Strike* denotes the strike of the put warrant. The time to maturity of the product, *TtM*, is represented in years.

Moreover, we use information on the credit spreads of the issuing bank, default-free spot rates, and the volatility of the underlying asset. We interpolate credit default swap (CDS) rates with maturities of 0.5, 1, 2, 3, 4, 5, and 7 years derived from Thomson Reuters Datastream linearly in the time dimension to match the time to maturity of the CDS to the time to maturity of the SFP. We use default-free spot rates provided by Deutsche Bundesbank to calculate the spot rate, r, for the remaining lifetime of the SFP. The volatility of the underlying, *VOLA* is derived from daily settlement prices of EUREX call and put options with the DAX performance index as the underlying asset. We follow the approach advocated by Baule, Entrop, and Wilkens (2008), among others, and use a two-dimensional interpolation in terms of time to maturity and strike to find an appropriate volatility estimate for each SFP and day of the sample period.

The number of products that we consider is lower than that depicted in Table 1 for the several reasons. We remove products with an endless maturity. This leaves us with as many as 19,727 put warrants and 24,431 discount certificates.

TABLE 2 Treated versus nontreated products

	Nontreated products		Treated products		
	Mean	***SD***	**Mean**	***SD***	***t*-test**
Put warrants					
$MONEY^{PUT}$	−0.072	0.142	−0.072	0.141	0.04
TtM	0.504	0.632	0.516	0.625	−1.33
SHARES	3,118	21,280	3,941	21,116	−2.606***
Discount certificates					
MONEY	0.154	0.266	0.153	0.264	0.261
TtM	0.656	0.535	0.658	0.542	−0.371
SHARES	104.08	1,361.3	154.44	1,641.38	−3.399***

Note. This table reports the mean and standard deviation (*SD*) of *MONEY*, *TtM*, and *SHARES* for treated products (those that match complementary products sold) and nontreated products measured on 3 successive days before the treatment. The treatment date of put warrants (discount certificates) is when the matched discount certificate (put warrant) is sold for the first time. Nontreated products are the outcome of a matching routine. For each treated product, we search nontreated products from the same issuer and priced on the same calendar days as treated products. Nontreated products are allowed to differ from treated products by a strike difference of no more than 100 index points and no more than 8 weeks in *TtM*. The *t*-test reports result from equality tests of nontreated versus treated products. *** indicate that the coefficient is significant at the 1% level.

For some SFPs, we lack relevant information necessary to determine TVs of the product, such as the volatility of the underlying. Thus, SFPs are not considered when we fail to determine an implied volatility for their *Strike*–maturity or *CAP*–maturity combination or when we do not have price data. Because of missing credit-risk information, we do not consider SFPs issued by Vontobel.

Our theoretical considerations above open up two possibilities for complementarity: (a) Pricing matching put warrants after selling discount certificates and (b) pricing matching discount certificates after selling put warrants. As shown in Table 1, the case with a discount certificate being offered first is far more common. Nevertheless, we consider both possibilities: The effects stemming from (a) discount certificates' demand on the pricing and issuance of put warrants and (b) put warrants' demand on the pricing and issuance of discount certificates. The sample we will use considers only issuers with various types of SFPs outstanding to test whether issuers engage in cross-pricing in products with offsetting payout profiles. Therefore, in most analyses, we then do not consider SFPs issued by UBS and RBS.

2.3 | Cross-pricing effects

The first step of our analysis involves potential price changes for put warrants when retail investors purchase discount certificates. In this case, issuers have an incentive to reduce the price of the complementary product to attract order flow and exploit the complementarity of these products. In the following, we test whether put prices decline after discount certificates have been sold. To investigate such a price effect, it is necessary to measure changes in put prices that are not caused by other factors, such as movements in the prices of the underlying securities. Therefore, we use a difference-in-differences approach. Our treatment group consists of matching put warrants, the corresponding discount certificates of which were sold for the first time to retail investors on a particular day.[5] To measure price changes, we consider several days of put price data before and after retail investors purchased discount certificates.

We compare the price changes of these matching puts before and after treatment (which is the purchase of discount certificates) with those of a control group. In this control group, we do not include all put warrants outstanding; rather, we employ a matching strategy to find control put warrants for each put that accompanies a purchased discount certificate. Control puts are selected in the following way. First, the control put has to be issued by the same issuer and has to be available in the market at the same point in time as the treated put. Thus, we employ issuer and calendar day matching. This ensures that all issuer-specific effects, such as differences in credit risk, and all market movements affecting treated and control puts alike can be filtered out. Second, the strike and the time to maturity of the control put are allowed to vary by no more than 100 index points and 40 trading days relative to the treated put. These restrictions ensure that the control put is relatively similar to the treated one. Treated puts for which we do not find a control put are not considered in the following analysis. Table 2 depicts the characteristics of treated and nontreated puts and shows that the two groups do not differ significantly in their features. This is required to attribute differences to the event of discount certificates being purchased by

[5]We consider both discount certificates that were issued and directly purchased and discount certificates that were issued and only purchased after some time has passed.

retail investors. In the table, the average number of traded shares, *SHARES*, shows that treated put warrants are more intensely traded than their respective control puts. Although we do not use the put demand in our matching routine, we will put particular emphasis on it in our difference-in-differences approach.

Our baseline difference-in-differences estimation is as follows:

$$\Delta PRICE_{it}^{PUT} = \beta_1 \cdot POST_{it} + \beta_2 \cdot TREAT_i + \beta_3 \cdot POST_{it} \cdot TREAT_i + \epsilon_{it}, \tag{1}$$

where $\Delta PRICE^{PUT}$ denotes the timely change in put price. Note that the timely change in put prices accounts for omitted variables in the level of prices. *POST* is a dummy variable that equals 1 after the treatment, regardless of whether put warrant i is in the treatment or control group, and 0 otherwise. *POST* captures all effects that are relevant for both types of warrants after the treatment. *TREAT* is a dummy variable equal to 1 for put warrants in the treatment group. It controls for all time-invariant differences in price changes between the two types of put warrants. The interaction term between *POST* and *TREAT* is the central term as its coefficient captures the additional mean change in prices of treated puts that is related to the selling of discount certificates. When estimating Equation (1), we specify that the error term, ϵ, contains a fixed effect for each warrant, which is perfectly collinear with the dummy variable *TREAT*. It is also perfectly collinear with dummy variables for issuers, and all other warrant-specific characteristics that are time constant.

Panel A of Table 3 presents the results based on put price changes that are observed 3 days before and 3 days after the discount certificates of the matching puts were purchased for the first time. In Column 1, we consider all treated puts with their respective control puts irrespective of the number of discount certificates sold. We find that the coefficient on the interaction term is negative but does not differ significantly from zero. One reason for this could be that issuers do not reduce their put prices when they have sold very few discount certificates. Therefore, in Column 2, we focus on those treated put warrants when at least 10,000 shares of the discount certificate were traded on the day it was first demanded. To capture this effect, we have two interaction terms, one for discount certificates with a low number of traded shares and another for when the number of trades is above 10,000. Now, we observe that the interaction term for puts with intensely traded discount certificates has a significantly negative effect on the put price change. We yield further support by examining subsamples based on whether the treated and nontreated puts belong to a certificate that was intensely traded on the first day (the results are available upon request). Thus, the prices of matching puts are reduced when a substantial number of discount certificates are sold. This is in line with the reasoning that issuers attempt to exploit dependencies in their SFP portfolios.

However, an alternative explanation is that the demand for the put warrant and not the demand of the discount certificate is causing the price change. The so-called order-flow hypothesis states that issuers increase their prices when retail investors begin to intensely purchase products, and they reduce prices when they repurchase the products (Baule, 2011). In Table 2, treated puts have a higher number of traded shares than nontreated put warrants. Thus, it could be that treated puts are in the second stage of the order-flow hypothesis, whereas nontreated puts are in the first. Therefore, we control also for the demand stemming from put warrants. In Column 3, we add traded shares of put warrants as additional explanatory variable, in Column 4 we further control for the moneyness and time to maturity of the put warrants, issuers' credit risk as captured by the 1-year CDS spread, interest rate, *RATE*, and volatility, *VOLA*. The latter three independent variables might be relevant because put price changes might be caused by price changes of the underlying securities, albeit we consider only several trading days. We find that neither the size nor significance of the coefficients on the interaction terms changes when we add these controls. To exclude possible interaction effects between the demand for put warrants and the demand for discount certificates, as only the latter should determine the treatment effect, we exclude all put warrants for which we observe trading activity in the 14 days before the discount certificate is sold (Column 5). Thus, we focus on those put warrants that are very likely not heavily demanded. With this restriction on the sample, we still find a negative and significant coefficient on the interaction effect of highly treated put warrants. Therefore, we conclude that the cross-pricing effects we measure for put warrants are caused by the demand for discount certificates and not by the demand for put warrants themselves.

Issuers may not only reduce put warrant prices when they sell matching discount certificates intensely, but they may also reduce prices of discount certificates when they sell put warrants intensely. Therefore, we repeat our analysis by investigating discount certificates, which we model as being treated when the respective put warrant is sold intensely. Table 2 depicts the characteristics of treated and nontreated discount certificates and shows that the two groups do not

TABLE 3 Cross-pricing when complementary products are sold

Panel A: PUTS	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**
POST	−0.014***	−0.014***	−0.014***	−0.014***	−0.025***
	(0.003)	(0.003)	(0.003)	(0.004)	(0.006)
POST × *TREAT*	−0.004				
	(0.004)				
POST × *lowTREAT*		0.000	−0.000	0.002	0.002
		(0.004)	(0.004)	(0.004)	(0.005)
POST × *highTREAT*		−0.054***	−0.052***	−0.068***	−0.112***
		(0.014)	(0.014)	(0.014)	(0.024)
log(1 + *SHARES*)			0.003***	0.001***	
			(0.000)	(0.000)	
$MONEY^{PUT}$				3.916***	3.828***
				(0.074)	(0.109)
$(MONEY^{PUT})^2$				−2.977***	−2.961***
				(0.120)	(0.141)
TtM				0.895***	0.022
				(0.214)	(0.277)
CDS				0.000***	0.000***
				(0.000)	(0.000)
VOLA				0.951***	1.048***
				(0.077)	(0.150)
RATE				33.64***	21.285***
				(3.100)	(3.542)
No. of observations	42,280	42,280	42,280	40,566	20,993
No. of puts	6,479	6,479	6,479	6,189	3,115
F-test	30.67***	23.02***	27.03***	376.7***	185.3***
Panel B: DISCOUNTS	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**
POST	0.000***	0.000***	0.000***	0.000***	0.001***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
POST × *TREAT*	−0.000				
	(0.000)				
POST × *lowTREAT*		−0.000	−0.000	−0.000	−0.000***
		(0.000)	(0.000)	(0.000)	(0.000)
POST × *highTREAT*		−0.001***	−0.001***	0.000	0.000
		(0.000)	(0.000)	(0.000)	(0.000)
log(1 + *SHARES*)			0.000	0.000***	
				(0.000)	(0.000)
MONEY				0.173***	0.173***
				(0.003)	(0.003)
$MONEY^2$				−0.091***	−0.093***
				(0.003)	(0.003)
TtM				−0.041***	−0.017**
				(0.007)	(0.007)
CDS				0.000***	0.000***
				(0.000)	(0.000)

(Continues)

TABLE 3 (Continued)

Panel B: DISCOUNTS	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**
VOLA				−0.081***	−0.078***
				(0.005)	(0.006)
RATE				−1.26***	−0.858***
				(0.064)	(0.081)
No. of observations	88,012	88,012	88,012	84,285	64,727
No. of discounts	13,526	13,526	13,526	12,881	9,565
F-test	11.18***	10.23***	7.87***	766.4***	633.5***

Note. This table reports the results from difference-in-differences estimations of price changes of put warrants (Panel A) and discount certificates (Panel B) around the day that their matching complementary products were sold to retail investors for the first time. Nontreated products come from the same issuer and have a maximum absolute *Strike* or *CAP* difference of 100 index points and a maximum maturity difference of 40 trading days. All specifications contain a product-specific fixed effect, which is perfectly collinear with the dummy variable *TREAT*. Column 5 is based on products, which have not been traded. Standard errors clustered on products are reported in parentheses. ***, and ** indicate that the coefficient is significant at the 1%, and 5% levels, respectively.

differ significantly in their features. They do, however, differ with respect to the number of traded shares: Treated discount certificates are more often traded than nontreated discount certificates.

Panel B of Table 3 provides the results from the difference-in-differences estimations. We find that the interaction term for discount certificates with intensely traded put warrants has a significantly negative effect on the price change of the discount certificates. This holds regardless of whether or not we control for retail investors' demand for discount certificates (Column 2 vs. Column 3). The effect vanishes, however, when we control for the features of the discount certificates (Column 4). Once we exclude possible effects stemming from the demand for discount certificates in Column 5, we find a significant effect for discount certificates whose matching puts are only moderately traded.

Several reasons explain why cross-pricing is more relevant for the case of put warrant prices. For example, put warrants have the same payoff profile than put options. Therefore, investors seeking to purchase put warrants may also use the option market to arrange their investment implying that issuers of put warrants do not only face competition from other issuers of put warrants but also from the market for put options. Indeed, Bartram and Fehle (2007) document competition effects between the two markets on which warrants and options are traded. Also, the number of traded shares for put warrants is substantially larger than for discount certificates, which indicates that it is more difficult for issuers to attract considerable order flow in discount certificates for risk management purposes. Finally, as documented in Table 1, discount certificates are more often issued before the put warrant is brought to the market, also indicating that cross-pricing may be more relevant more the case of put warrants.

2.4 | Margins and the arrival of matching SFPs

Our next step is more general in the sense that we ignore demand for the complementary product and use only availability of a matching SFP. For instance, issuers may offer discount certificates at more favorable margins after the issuance of the matching put than before, because issuing (and selling) a put warrant and discount certificate to (different) retail investors at the same time implies that issuers' risk exposure is reduced. To the contrary, simultaneously issuing a call and put may come with an increase in certificates' margins, as the resulting SFP portfolio of this combination entails higher overall risk exposure. Similarly, call warrants also only increase risk exposure, and thus, the margins of discount certificates are expected to increase. Equivalently, issuers may decrease margins for put warrants when matching discount certificates become available, which may result in a more favorable risk profile. At the same time, margins of put warrants are expected to increase when call warrants are available as this increases the overall risk exposure of the issuer. In the following, we use time-series regressions to determine whether the margins of put warrants and discount certificates change when another matching SFP is issued. We use margins and not changes in prices, as our time series cover long time periods, in which the price changes of underlying securities are more pronounced than in the short run. We describe how we calculate margins in Appendix B.

TABLE 4 Margins and product availability

	n	Mean	*SD*	*t*-test
Put warrants				
Discount only	179	−0.0012	0.1239	−0.13
Discount and Call	194	0.0519	0.3689	1.96**
Call only	498	0.0595	0.3124	4.25***
Bonus	35	0.0888	0.3320	1.58*
Discount certificates				
Put only	717	0.0102	0.2946	0.92
Put and Call	1,202	0.0157	0.2990	1.82*
Call only	316	0.0412	0.3105	2.36**
Bonus	198	0.0696	0.3091	3.17***

Note. This table shows summary statistics of the α coefficient from the model $V_t = \alpha{\cdot}AVAILABLE_t + \beta{\cdot}MONEY_t + \gamma{\cdot}TtM_t + \epsilon_t$, which is estimated on credit-risk-adjusted margins, V_t, separately for each put warrant and each discount certificate. $AVAILABLE_t$ denotes a dummy variable that equals 1 when a matching SFP becomes available, zero otherwise. Summary statistics of α for put warrants (upper panel) are reported for when a matching discount certificate is issued only (Discount only), when both a matching discount and call are issued (Discount and Call), when only a matching call is issued (Call only), and when a bonus certificate is issued with a *Strike* equal to the put warrant's *Strike*. Summary statistics of α for discount certificates (lower panel) are reported for when a matching put is issued only (Put only), when both a matching put and call are issued (Put and Call), when only a matching call is issued (Call only), and when a bonus certificate is issued with a *Strike* equal to the discount certificate's *CAP*. We report the number of single regressions (= number of put warrants in the upper panel and number of discount certificates in the lower panel) in each subgroup (n), the mean of the coefficient estimates, and the standard deviations of the coefficients (*SD*). The *t*-test reports the results of whether the average coefficient estimate equals zero. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

We employ linear regression models to determine whether the margins of put warrants and discount certificates are higher or lower after the issuance of a matching SFP. We perform a time-series regression on margins for each put warrant and each discount certificate according to the following model:

$$V_t = \alpha{\cdot}AVAILABLE_t + \beta{\cdot}MONEY_t + \gamma{\cdot}TtM_t + \epsilon_t, \tag{2}$$

where $AVAILABLE_t$ denotes a dummy variable that equals 1 when a matching SFP is available, zero otherwise. We require data on the margins of put warrants or discount certificates on at least 10 trading days before and after the other SFP is issued.

Table 4 summarizes the coefficient estimates on availability separately for put warrants (upper panel) and discount certificates (lower panel). We distinguish the effects when complementary products but not noncomplementary products are issued, when both complementary and noncomplementary products are issued and when noncomplementary products but not complementary products are issued. The average effects of availability between complementary products only and noncomplementary products only (which means call warrants) are expected to differ because issuers' risk exposure increases in the latter but not in the former case. Therefore, in the case of a matching complementary and noncomplementary product, the issuer will be less likely to offer discount certificates or put warrants at lower margins. We observe an interesting pattern in the availability coefficients. For put warrants, the coefficient estimates on discount certificates only are, on average, insignificant, whereas those on discount and call warrant availability and call warrants only are significantly positive. In addition, the average size of the coefficient estimates is worth mentioning: Discount certificate only has an average coefficient estimate of −0.001, whereas discount and call availability yields an average estimate of 0.052, and finally, call only has an average estimate as high as 0.059. A similar pattern emerges for availability coefficient when we use margins of discount certificates as dependent variable: Put only has an average coefficient estimate of 0.010, whereas put and call availability yields an average estimate of 0.016, and finally, call only has an average estimate as high as 0.041. Thus, put warrants' and discount certificates' margins are higher when the issuer has a matching product available that increases rather than decreases its risk exposure. The average insignificant coefficient estimates on certificate only for put warrants' margins and put only for discount certificates' margins imply that issuers do not offer a discount when put warrants or discount certificates receive diversifying matching products.

We also shed light on bonus certificates here because, in a similar vein to calls only, bonus certificates do not help reduce issuers' risk exposure and because we have a sufficient number of matching bonus certificates to conduct this analysis. Contrary to warrants and discount certificates, bonus certificates have a knock-out barrier

TABLE 5 Issuance strategies for SFP portfolios

	Mean	*SD*	Skewness	Kurtosis	p25	p50	p75
Panel A: All SFPs							
Put	−211.96	1,097.09	0.44	4.03	−856.85	−249.00	317.44
Call	−341.81	1,239.90	−0.67	5.18	−917.44	−209.06	359.66
Discount certificate	−548.45	1,584.11	0.13	3.31	−1,648.30	−607.08	495.05
Bonus certificate	−1,575.53	1,043.30	−0.74	5.46	−2,185.04	−1,381.53	−823.44
Panel B: SFPs with less than 45 days until maturity							
Put	−208.07	570.85	0.48	6.21	−541.45	−199.98	116.77
Call	−96.54	565.40	−0.11	8.53	−401.60	−70.89	254.29
Discount certificate	−395.38	887.15	−0.10	2.35	−1,104.95	−370.32	295.05
Bonus certificate	−1,237.71	409.86	−0.52	1.76	−1,615.01	−1,115.01	−918.53
Panel C: SFPs issued before Lehman collapse							
Put	−90.41	1,168.19	0.79	3.90	−836.71	−249.99	428.68
Call	−180.80	1,171.46	−0.18	5.35	−725.43	−120.89	476.63
Discount certificate	−807.38	1,814.54	0.14	3.33	−1,961.58	−935.01	383.26
Bonus certificate	−1,730.13	1,101.19	0.08	6.62	−2,423.75	−1,670.44	−925.29
Panel D: SFPs issued after Lehman collapse							
Put	−266.60	1,059.09	0.20	3.89	−863.39	−248.34	282.73
Call	−418.86	1,264.15	−0.85	4.96	−1,001.66	−263.31	309.51
Discount certificate	−418.75	1,437.68	0.28	2.90	−1,487.5	−453.60	553.03
Bonus certificate	−1,505.65	1,008.56	−1.19	5.08	−2,043.71	−1,284.49	−774.05

Note. ITM: in-the-money; OTM: out-of-the-money; SFP: structured financial product; TtM: time to maturity.

Note. This table summarizes the issuance strategies of SFP portfolios issued between January 2008 and June 2010 for put and call warrants and discount and bonus certificates. We calculate the following distances at the time of issuance and report summary statistics: For put warrants, we calculate *Strike−DAX*, where *DAX* denotes the current value of the underlying. For call warrants, this distance is *DAX−Strike*. For discount and bonus certificates, it is *CAP−DAX* and *DAX−Strike*, respectively. Positive distances denote ITM contracts; negative distances indicate OTM contracts. Panel A comprises the full sample period, whereas Panel B is restricted to SFPs with a TtM of less than 45 days, still covering approximately 3,000 put and call warrants each and 700 discount certificates. Panel C comprises the period of the Lehman collapse and Panel D the post-Lehman period.

and a strike determining the payoff of the product. More interesting is the strike, as the payoff of the product follows one to one the value development of the underlying if the value of the underlying is higher than this upper barrier. Therefore, we define a matching bonus certificate as having an upper value bound equal to the put warrant's strike or the discount certificate's *CAP* and a time to maturity that differs by no more than 5 trading days. Table 4 shows that we have 198 discount certificates with matching bonus certificates in our sample.[6] For discount certificates, the coefficient estimate on the availability of a matching bonus certificate is significantly positive. For put warrants, we also find a significantly positive availability coefficient. This is in line with our previous findings and with the argument that having other SFPs that increase rather than decrease the issuers' risk exposure entails higher margins. Noteworthy is that the average coefficient estimate on availability is lowest for puts only and discounts only, followed by put–discount and calls available at the same time. For calls only, the average coefficient on availability is higher than that for the complementary product and call availability, but it is lower than that for bonus availability.

2.5 | Pooled margin regressions

We next turn to the portfolio perspective. Issuers may not only consider the availability of matching products when pricing SFPs but also instead consider their entire portfolio of offered SFPs. Thus, we continue with the observation that the payoff profiles of SFPs exhibit nonzero skewness and kurtosis different from three. Moreover, the moments of these products change together with the moneyness of the products. For instance, the skewness of a warrant with a strike of 100 for current values of the underlying between 80 and 120 ranges between 1.56 and 4, all other factors being equal. Moreover, the kurtosis ranges from 6.25 to 24.03. Similarly, the skewness of an individual put warrant decreases, ceteris paribus, for an increasing strike. Thus, when issuing a portfolio of SFPs, the issuer may not only consider demand

[6] Overall, we have 960 matches between discount and bonus certificates: 409 discount certificates were issued after the bonus certificate and 551 discount certificates were issued before the bonus certificate. However, among these 551 matches, we have some bonus certificates that match with the same discount certificate. Although we are only examining the margins of discount certificates, the number of observations drops substantially because each discount certificate is considered only once.

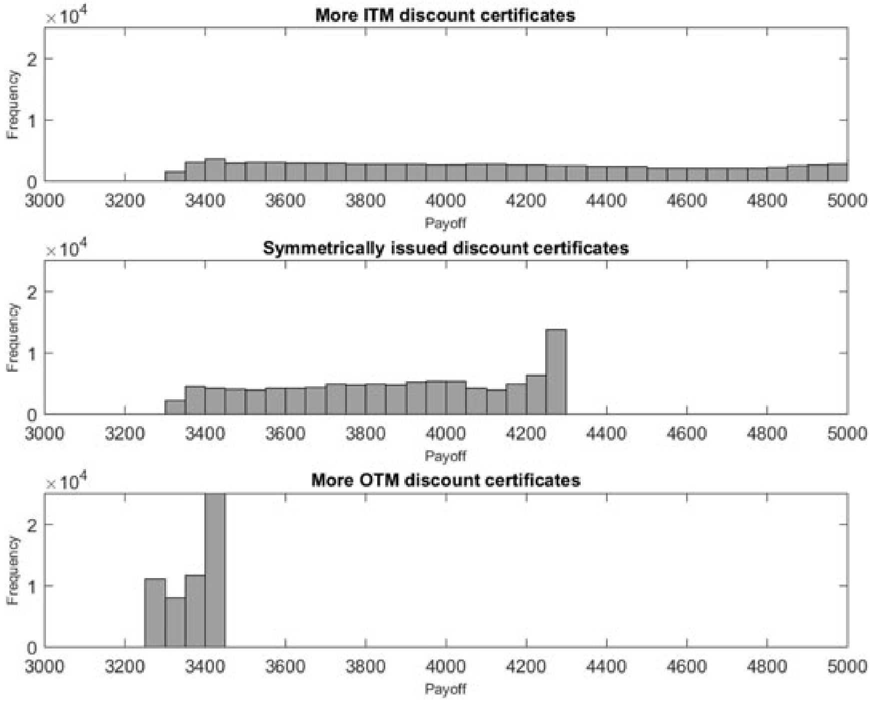

FIGURE 1 Payoffs of various put–discount certificate portfolios. The figure shows the probability distribution of the payoffs of several SFP portfolios. All portfolios contain an identical portfolio of put warrants combined with different portfolios of discount certificates. The put warrant portfolio consists of more OTM than ITM put warrants in all three panels (strikes that are generally smaller than the price of the underlying at the time of issuance). The discount certificate portfolio is issued with different strategies. The portfolio in the top panel consists of more ITM than OTM discount certificates (*CAP*'s that are generally larger than the price of the underlying at the time of issuance). We label this the demand motive. The portfolio in the middle panel is issued symmetrically around the current price of the underlying without any additional considerations. The portfolio in the bottom panel consists of more OTM than ITM discount certificates (*CAP*'s that are generally smaller than the price of the underlying at the time of issuance). We call this the hedging motive. To generate the probability distributions, we simulated 100,000 asset paths following a geometric Brownian motion over 1,000 trading days, each starting ATM. Then, we calculated the payoffs of the SFP portfolios for these simulated asset paths. ATM: at-the-money; ITM: in-the-money; OTM: out-of-the-money; SFP: structured financial product

aspects but also the higher moments of future payouts. In this situation, not only the higher moments of a single product but also those of the portfolio after issuance are relevant. Of course, these are substantially influenced by the composition of the portfolio, that is, by the purchase intensity.

We first demonstrate how issuers can influence the payoff distribution of their SFP portfolios by simulating different SFP portfolios. We consider the case of an issuer that brings 43 different put warrants to market. The issuer follows the demand for put warrants and issues a portfolio that contains more OTM than other put warrants. Note that such a pattern is consistent with the observations from our sample (see Table 5). During market downturns, the issuer will face high payouts resulting from its put portfolio. However, by combining the portfolio with discount certificates that lead to smaller payouts during market downturns, the issuer is able to create a sort of hedge for these periods. We demonstrate that the effectiveness of this hedge depends on the design of the discount certificate portfolio.

Figure 1 shows the payouts of the put portfolio combined with three different discount certificate portfolios and visualizes the case of strategic discount certificate issuance. The upper panel combines the put portfolio with a portfolio of 43 discount certificates that are issued following discount certificates demand.[7] These certificates exhibit large *CAP*'s, on average. Buyers can participate in positive (and negative) market developments; on average, the certificates are offered ITM. The combined portfolio results in a wide distribution of future payouts. The second panel illustrates the payouts of the put portfolio combined with a discount certificate portfolio symmetrically issued around the current value of the underlying. This portfolio contains as many ITM as OTM discount certificates. As can be seen from the figure, the payout distribution is more compact. Finally, the lower panel of

[7]As can be seen from Table 5, discount certificates in our sample are issued according to this strategy, on average.

Figure 1 shows the payout distribution of the put portfolio combined with a portfolio consisting of discount certificates following the motive to exploit complementary payout profiles of products. The certificates within the discount portfolio are mostly offered OTM. Thus, they are very similar to a riskless investment opportunity with some (small) probability of default. With this discount certificate portfolio, the payouts of the portfolio are the most compact and smallest on average. Note that this hedge portfolio does not consist of matched put–discount pairs. If one were to consider a portfolio of matching put warrants and discount certificates, the resulting payoff distribution would be deterministic. Thus, issuers can, at least partly, influence the probability distribution of their SFP portfolio by strategically bringing new products to market. Note that this argumentation is essentially equivalent to our argumentation at the product level, but takes the increasing number of bulk issues of SFPs into account.

We observe that, especially from a risk management perspective, the payout distribution at the portfolio level is paramount. This observation is underlined by the issuance patterns of suppliers. In total, our data set contains information about 955 issuance days for put and call warrants and discount and bonus certificates. Although the minimum number of products that an issuer brings to market at a given point in time is one, and the 25% quantile comprises three products, on average, an issuer brings 69 products to market at a given point in time. Of course, the distribution is highly skewed, with a median of 18 products and a 75% quantile and maximum number of 81 and 1,376 products, respectively. Hence, in many cases, issuance decisions are made at the portfolio level. Similarly, pricing decisions may be correlated with the risk measures of complementary SFP portfolios.

Comparable to the product level (see Section 2.4), issuers may take the availability of other products in their SFP portfolio into account when pricing their products. The recent literature has identified several factors that explain why prices of SFPs substantially exceed their TVs (Burth, Kraus, & Wohlwend, 2001; Carlin, 2009). As noted by Henderson and Pearson (2011), issuers of SFPs face transaction costs for hedging their liabilities, marketing costs, and fees for registering and listing the securities on an exchange and have to recover the staffing costs associated with designing, modeling, and valuing the products. In line with this observation, issuers may pass on costs for issuing hedging instruments to their customers (Henderson & Pearson, 2011), which may partly explain the difference between prices and TVs. By including information on the composition of the put warrant portfolio, we consider the potential payouts associated with the put warrant portfolio of the issuer and thus focus on the hedging costs and risk exposure of complementary products associated with the discount certificate. We hypothesize:

H2: *The margins of discount certificates include a pricing factor for the risk measures of complementary put portfolios.*

2.5.1 | Descriptive statistics

We first present some descriptive statistics and discuss the issuance patterns of SFP issuers in our sample. To evaluate the issuance behavior, we calculate the distances between the strikes (for warrants and bonus certificates) and the *CAP*'s (for discount certificates) and the current value of the underlying. These distances allow us to assess whether the SFPs are issued ITM or OTM. Positive distances denote ITM contracts, whereas negative distances indicate OTM contracts. Table 5 summarizes the manner in which issuers bring their products to market. Panel A covers the full sample. We observe that issuers tend to issue OTM products, on average. Considering put warrants, this behavior is consistent with demand reported for options (Bollen & Whaley, 2004; Gârleanu et al., 2009). For discount certificates, however, we expect a higher demand for ITM certificates, as these allow customers to participate in positive market developments. Because, moreover, the issuance patterns are not symmetric and not centered around the current value of the underlying, issuers seem to take some other factors into account when issuing SFPs. One could argue that issuers bring these OTM products to market to be prepared for the possibility of market movements or changed their issuance patterns in response to the Lehman crisis. To control for these arguments, we study several subsamples. As tabulated in Panel B of Table 5, on average, suppliers also issue products OTM even if they exhibit a rather short lifetime of less than 45 days. Thus, issuers do not seem to bring these OTM products to market with respect to long-term market expectations. Finally, Panels C and D present summary statistics for the period of the Lehman collapse and the post-Lehman period. Overall, the issuance strategies are relatively stable over time, although the tendency to issue warrants OTM has increased in the post-Lehman period.

A shortcoming of our portfolio approach is that we do not know the actual risk exposure of the issuers and cannot incorporate information about the number of products sold to retail investors in our study. As many transactions are OTC, we do not have information about the complete portfolios of issuers and cannot estimate the probability distribution of the current portfolios. However, we can determine characteristics that influence the payout profile of the issuer (strikes, *CAP*'s) of all currently outstanding and newly issued products at every point in time during our sample period. Thus, we can estimate statistics of the characteristics of all outstanding certificates that allow us to analyze the strategic focus when issuing SFPs—as indicated above. By offering SFPs with payoff characteristics biased toward ITM or OTM products, the issuer is able to influence future payouts and balance expected payouts and payouts under rare market developments. Although, for example, an asymmetric put warrant portfolio with a bias toward low strikes, that is, with a positive skew, yields lower expected payouts, the resulting distribution of future payouts may simultaneously influence credit constraints based on value at risk. An asymmetric put warrant portfolio with a bias toward high strikes (negative skew), by contrast, is associated with high expected payouts.

2.5.2 | Results

We examine how margins of discount certificates are correlated with the moments of put warrant portfolios. We restrict our study to the case where discount certificates are issued first. We use monthly data, where prices of discount certificates used to calculate credit-risk-adjusted margins are the ones that we observe on the last day of each month. As independent variables, we include several measures that characterize the design of the put warrant portfolio. First, we include the kurtosis as an independent variable. The rationale behind this is that more put warrants with strikes in the tail of the distribution are associated with higher (higher potential) payouts (in rare market events). Thus, the issuer faces higher payouts, higher risk, and potentially tighter credit constraints when downside risk is considered. We estimate our regressions according to the following model:

$$V_{it} = \alpha + \beta_1 \cdot KURT_{it}^{PUT} + \beta_2 \cdot TtM_{it} + \beta_3 \cdot MONEY_{it} + \beta_4 \cdot MONEY_{it}^2 + \beta_5 \cdot \log(1 + SHARES_{it}) + \sum_{j=1}^{29} \beta_{(5+j)} \cdot TIME_{jt} + \sum_{j=1}^{24} \beta_{(34+j)} \cdot ISSUER_{ji} + \epsilon_{it}, \tag{3}$$

where $KURT_{it}^{PUT}$ denotes the kurtosis of the distances between strikes and the current value of the underlying of the overall outstanding put warrant portfolio for each issuer.

Panel A of Table 6 shows the results. In Columns 1–6, we control for unobserved heterogeneity using a full set of time- and issuer-specific dummy variables and utilize Newey–West standard errors. Time fixed effects filter out all external effects that change at the same rate for all outstanding certificates. The results of our baseline regression in Column 1 show that a higher kurtosis of the put warrant portfolio is indeed associated with higher margins of the discount certificates. This finding is consistent with the hypothesis that issuers consider the payouts and risk exposure of complementary products in their pricing decisions. To rule out correlated demand of retail investors, we restrict our sample to discount certificates that were never traded in Column 2. The results suggest that the observed correlation between the kurtosis of the put portfolio and the margins of discount certificates is not driven by demand. Next, we study subsamples to analyze possible competition effects and shed additional light on possible demand effects. Our argument is that with less competition and higher demand, higher margins can be collected more easily, and hence, issuers may further increase margins. However, the result is similar for discount certificates that face fewer than four competing products (Column 3).[8] Following the idea advanced by Baule and Blonski (2015) and Entrop et al. (2016), we create dummy variables to capture whether the *CAP* is a round number, as round caps (strikes) are attention-grabbing features and consequently these products are expected to be more intensely demanded. We find similar results for discount certificates that have a *CAP* that can be divided by 500 without a remainder (Column 4). Moreover, the results hold for the period before the Lehman collapse in 2008 (Column 5) and for the 2009–2010 post-Lehman period (Column 6).

[8]Competing discount certificates are from other issuers and are allowed to differ in their moneyness by no more than ±5% and reference dates by no more than ±14 days from the certificate being considered (see, e.g., Baule, 2011; Entrop et al., 2016).

TABLE 6 Pooled margin regressions

	(1) Baseline	(2) No demand	(3) Competition	(4) Round 500	(5) Lehman	(6) Post-Lehmann	(7) ITM
Panel A							
$KURT^{PUT}$	0.050***	0.061***	0.054***	0.048***	0.064***	0.069***	
	(0.002)	(0.002)	(0.004)	(0.003)	(0.002)	(0.003)	
$MONEY \times KURT^{PUT}$							0.009***
							(0.001)
TtM	0.541***	0.549***	0.599***	0.535***	0.581***	0.529***	0.548***
	(0.001)	(0.002)	(0.002)	(0.003)	(0.002)	(0.001)	(0.001)
$MONEY$	−0.181***	−0.173***	−0.132***	−0.166***	−0.025***	−0.188***	−0.202***
	(0.003)	(0.003)	(0.003)	(0.005)	(0.006)	(0.003)	(0.005)
$MONEY^2$	0.018***	0.017***	0.013***	0.014***	−0.019***	0.022***	0.023***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.003)	(0.001)	(0.001)
$\log(1 + SHARES)$	−0.000		−0.000	−0.000*	0.000	−0.000**	0.000***
	(0.000)		(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Time effects	Yes	Yes	Yes	Yes	Yes	Yes	No
Issuer effects	Yes	Yes	Yes	Yes	Yes	Yes	No
Issuer × time effects	No	No	No	No	No	No	Yes
No. of observations	118,801	72,640	26,548	26,330	29,056	89,745	78,273
No. of discounts	13,883	9,567	3,905	2,799	4,669	12,537	
F-test	10,698.4***	7,726.2***	6,807.0***	2,523.8***	6,905.5***	12,986.3***	5,599.4***

	(1) Lehman	(2) Post-Lehmann	(3) ITM	(4) Baseline	(5) Lehman	(6) Post-Lehmann
Panel B						
EXP^{PUT}	−0.565***	0.375***				
	(0.061)	(0.051)				
$MONEY \times EXP^{PUT}$			0.458***			
			(0.021)			
$\Delta SKEW^{PUT}$				−0.001	−0.014***	0.009***
				(0.001)	(0.001)	(0.001)
TtM	0.575***	0.530***	0.549***	0.53***	0.568***	0.522***
	(0.002)	(0.001)	(0.001)	(0.002)	(0.002)	(0.002)
$MONEY$	−0.030***	−0.188***	−0.169***	−0.193***	−0.001	−0.251***
	(0.007)	(0.003)	(0.003)	(0.004)	(0.007)	(0.005)
$MONEY^2$	−0.016***	0.022***	0.025***	0.037***	−0.025***	0.059***
	(0.004)	(0.001)	(0.001)	(0.003)	(0.004)	(0.004)
$\log(1 + SHARES)$	0.000	−0.000**	−0.000***	0.000	0.000**	−0.000***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Time effects	Yes	Yes	No	Yes	Yes	Yes
Issuer effects	Yes	Yes	No	Yes	Yes	Yes
Issuer × Time effects	No	No	Yes	No	No	No
No. of observations	29,056	89,746	78,273	75,393	23,889	51,504
No. of discounts	4,669	12,537		9,299	4,354	8,095
F-test	6,416.3***	12,928.8***	6,963.5***	8,861.8***	6,470.8***	12,227.3***

Note. The regressions estimate the relationship between the credit-risk-adjusted margins of discount certificates as the dependent variable and the characteristics of the put warrant portfolio. Column 1 of Panel A shows our baseline regressions with the kurtosis of the distances between strikes of the put warrant portfolio and the current value of the underlying as our main independent variable. Column 2 only considers discount certificates that were never traded. Column 3 is restricted to discount certificates that face fewer than four competing products. Column 4 only considers certificates that have a *CAP* that can be divided by 500 without a remainder. In Column 5, we consider the period before the Lehman collapse, whereas Column 6 considers the post-Lehman period. Column 7 is restricted to ITM discount certificates. The first two and the last two columns of Panel B consider the period before the Lehman collapse and the post-Lehman period, respectively. Column 3 is restricted to ITM discount certificates, and Column 4 considers the full sample. For all models, the usage of fixed effects is depicted at the bottom of the table. Newey–West standard errors are given in parentheses. Models that do not contain Issuer × Time effects have clustered robust standard errors at the certificate level. ITM: in-the-money; TtM: time to maturity. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

In Column 7, we investigate whether all discount certificates are affected by this pricing factor in the same way. We analyze the relationship between the moneyness of the certificate and the kurtosis measure. We argue that OTM discount certificates are similar to riskless investment opportunities, which complicates the ability of the issuer to increase margins. On the contrary, ITM discount certificates face higher demand from retail investors and provide greater potential to hide margins due to the multiplier of the certificate and the discount associated with the *CAP*. Thus, we expect that the kurtosis measure of the put warrant portfolio is associated with higher margins, especially with increasing moneyness. We restrict our sample to ITM discount certificates and replace the set of time- and issuer-specific dummy variables with a set of Issuer × Time-specific dummy variables. This eliminates all observed and unobserved time–issuer-specific effects. We employ an interaction term to shed additional light on the relationship between the margins of discount certificates and the kurtosis measure of strikes of the put warrant portfolio of the issuer, as the kurtosis is perfectly collinear with the time-issuer effect. The coefficient provides evidence in support of our expectation. The correlation between the kurtosis measure and the discount certificates' margins increases with the certificates' moneyness.

Panel B of Table 6 presents the results for other moments of the put portfolio. Columns 1–3 focus on the relationship between the mean of the distances between the strikes of the put warrant portfolio and the current value of the underlying and the margins. Although the data we gather from the mean are not associated with potential credit constraints, they nonetheless provide us with insights about expected payouts of the put warrant portfolio. Note that the variable proxies for future payouts of the issuer's entire put portfolio and differs from the simple impact of a change in value of the underlying. As the mean increases, more put warrants are ITM and, thus, require payouts at maturity. Consequently, higher expected values are associated with higher payouts. For the period of the Lehman collapse (Column 1), we observe a significant negative relationship between the expected value of the distances between strikes of the put warrant portfolio and the current value of the underlying and discount certificates' margins. However, in the post-Lehman period (Column 2), this relationship becomes significantly positive. After the market turmoil and substantial price losses on equity markets, issuers faced large payouts for their SFP portfolios, especially for put warrants. Consequently, issuers adjusted their price setting for the complementary products. Next, we eliminate all time-issuer-specific effects and study whether we can confirm our above findings that this effect is increasing with discount certificates' moneyness (Column 3). The results highlight that higher expected payouts of the complementary put portfolio are associated with higher margins, especially for discount certificates with increasing moneyness. We argue that discount certificates with a higher moneyness provide more financial leeway to increase margins, as these are more difficult to duplicate.

Finally, we consider the skewness of the differences between the strikes of the put warrants and the current value of the underlying. In contrast to the other moments, the interpretation of the skewness measure is more complicated, as the skewness of a distribution is not influenced by its location.[9] In other words, two put warrant portfolios with different means, for example, one more OTM-oriented portfolio and one more ITM-oriented portfolio or, even more extreme, one portfolio that contains only ITM put warrants and one portfolio that contains only OTM put warrants, may exhibit the same skewness. Therefore, we consider time differences in the skewness measure instead of the level. Our expectation is the following: As the skewness measure increases, the tail of the distribution containing warrants with high strikes becomes longer or fatter than the side of warrants with low strikes. Hence, payouts associated with the complementary put warrant portfolio increase, and issuers could pass on their higher payouts with the discount certificates. For the skewness measure, we first consider the full sample period (Column 4) and observe no significant correlation with the margins of discount certificates. To further investigate this issue, we consider two subsamples focusing on the period of the Lehman collapse (Column 5) and the post-Lehman period (Column 6) and observe significant differences in the pricing of discount certificates. Although skewness enters Column 5 with a significantly negative coefficient, we observe a positive coefficient for the post-Lehman period.[10] Thus, our results are consistent with the larger coefficient on EXP^{PUT} in the post-Lehman period in Column 2 and provide evidence that the pricing of skewness changed due to the Lehman collapse. A positive skewness in the strikes of the put warrant portfolio implies that the portfolio contains some warrants with larger strikes and higher payouts. Hence, issuers pass these payouts on to retail investors. In conclusion, we find evidence in line with Hypothesis 2: The margins of discount certificates include a pricing factor for the risk exposure of the complementary put portfolio.

[9]The same is true for the kurtosis; however, the skewness is a measure of asymmetry and indicates that the tail on one side of the distribution is longer or fatter than that on the other side. In contrast, the kurtosis captures tail extremity in general, that is, it captures extreme values of the distribution on both sides.

[10]Note that the positive coefficient is consistent with findings of previous studies focusing on stock markets (Amaya et al., 2015; Chabi-Yo, 2012; Jacobs, Regele, & Weber, 2016; Meunier, 2016; Noussair et al., 2014). For example, Chabi-Yo (2012) shows that a portfolio consisting of a long position of stocks with the lowest realized skewness and a short position of stocks with the highest realized skewness generates an average return of 19 basis points/week. Furthermore, Barberis and Huang (2008) argue that, when investors make decisions according to prospect theory, assets with greater skewness have lower returns.

3 | ISSUANCE DEPENDENCIES

3.1 | Hypothesis

We complement our results and study issuance dependencies between SFPs. Issuers not only have incentives to offer complementary products at lower prices when they have sold substantial amounts of the matching SFP, but also may more likely bring complementary products to the market when they have not already issued a matching SFP. If issuers have sold many discount certificates and not yet issued a matching put, they have an incentive to issue a put warrant with the same features as those of the discount certificates. Issuing and selling put warrants with the same features as the discount certificates they have recently sold to retail investors allows issuers to keep their risk exposure at a moderate level. Therefore, we expect that the demand for a complementary product (e.g., discount certificate) has a positive effect on the probability of issuing a respective matching product (put warrant).

H3 *The probability of issuing a matching product depends on the demand for the complementary product.*

3.2 | Issuance of matching put warrants

We investigate the conditions under which discount certificates receive a matching put warrant. Our dependent variable is a dummy variable, DC_{it}^{PUT}, that equals 1 when a discount certificate i receives a matching put warrant in month t, zero otherwise. Our baseline model can be depicted as follows:

$$PROB(DC_{it}^{PUT} = 1) = \Phi(\beta_1 \cdot \log(1 + SHARES_{it}) + \beta_2 \cdot MONEY_{it} + \beta_3 \cdot TtM_{it} + \beta_4 \cdot Round_i^{500} + \beta_5 \cdot Round_i^{200} + \sum_{j=1}^{29} \beta_{(5+j)} \cdot TIME_{jt} + \sum_{j=1}^{11} \beta_{(34+j)} \cdot ISSUER_{ji} + \epsilon_{it}). \quad (4)$$

In addition to our introduced variables, we consider $Round^{500}$ ($Round^{200}$), which is a dummy variable that takes a value of one if the discount certificate has a CAP that can be divided by 500 (200) without a remainder, zero otherwise. We also control for time and issuer effects using a set of dummy variables. Since the number of traded discount certificates is highly skewed, we log-transform them.

Table 7 reports marginal effects from probit estimations.[11] We first conduct the estimation without including dummy variables for each issuer (Column 1) to use the full size of the data set with more than 24,000 discount certificates. We observe that discount certificates' log-transformed trades, $log(1 + SHARES)$, are significantly positive and, thus, that the probability of having a matching put increases in discount certificates' demand. This result does not change when we add a full set of issuer dummy variables or when we use the lagged and log-transformed number of trades instead of the contemporaneous figure (Column 2).

Interestingly, adding the second lag of aggregated log-transformed trades (which does not contain the lagged log of trades) shows that having highly lagged aggregated trades entails a lower probability of having a matching put warrant (Column 3). This indicates that the probability of receiving a matching put is not determined by the demand for certificates some months ago.[12] In Column 4, we use the dummy variable that is equal to 1 when the certificate is traded and find that it has a positive and significant effect on the probability of receiving a matching put. Finally, we modify the model to ensure that the demand effect does not capture discount certificates' features. Therefore, we use D_SHARES, which is a dummy variable that equals one if the product is traded in month t, zero otherwise. We find that D_SHARES retains its sign and significance when we add squared terms of moneyness and time to maturity (Column 5). Thus, we find strong evidence supporting Hypothesis 3: The probability of issuing a matching put warrant increases in the sales of discount certificates.

Next, we investigate nonlinear effects of discount certificates' moneyness on the probability that a matching put warrant is issued. We expect issuers to have greater incentives to issue a matching put warrant whenever the necessary payments at maturity are more likely to be subject to variation. Consequently, issuers have substantial

[11]We also test whether modeling a fixed effect for each discount certificate changes our findings by using a conditional logit specification (Andersen, 1970; Chamberlain, 1980). These fixed effects control for all time-consistent observable and unobservable issuer characteristics and are perfectly collinear with all time-consistent features of the certificates, such as dummy variables for round CAPs. Although neither the marginal effects nor significance levels differ substantially between the probit and conditional logit models, we do not report these results here.

[12]This finding should not be overemphasized because the lag of log-transformed trades is substantially correlated with the second lag of aggregated log-transformed trades. The correlation coefficient is 0.47.

TABLE 7 Probability of receiving a matching put

	(1)	(2)	(3)	(4)	(5)
$\log(1 + SHARES)$	0.001***				
	(0.000)				
$\log(1 + SHARES_{t-1})$		0.001***	0.001***		
		(0.000)	(0.000)		
$\log(1 + AGG\_SHARES_{t-2})$			−0.001***		
			(0.000)		
D_SHARES_{t-1}				0.007***	0.005***
				(0.001)	(0.001)
MONEY	−0.004***	−0.013***	−0.018***	−0.013***	
	(0.001)	(0.001)	(0.001)	(0.001)	
$MONEY^2$					−0.011***
					(0.000)
TtM	−0.004***	−0.003***	−0.007***	−0.003***	
	(0.000)	(0.001)	(0.001)	(0.001)	
TtM^2					0.000
					(0.000)
$Round^{500}$	−0.002***	−0.003***	−0.002	−0.003***	−0.000
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
$Round^{200}$	−0.001	−0.002**	−0.000	−0.002**	−0.001
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Time effects	Yes	Yes	Yes	Yes	Yes
Issuer effects	No	Yes	Yes	Yes	Yes
No. of observations	267,734	188,140	169,299	188,140	188,140
No. of discounts	24,431	18,827	18,314	18,827	18,827
χ^2	1,944***	3,033***	2,571***	3,030***	3,645***

Note. This table shows marginal effects from probit models of the probability that a discount certificate receives a matching put. The dependent variable equals 1 when a discount certificate receives a matching put in month t, zero otherwise. In Column 1, we also consider discount certificates from issuers that do not offer put warrants. In Columns 2–5, we restrict the sample to discount certificates from issuers that also offer put warrants. In Column 5, we consider squared terms of moneyness and TtM instead of their linear terms. Standard errors clustered at the level of discount certificates are in parentheses.
***, and ** indicate that the marginal effect is significant at the 1%, and 5% levels, respectively.

incentives to issue a matching put for ATM discount certificates, the payoffs of which are nonlinearly related to the value of the underlying, to exploit the complementarity of payout profiles. As moneyness increases, the influence of the nonlinearity in payoffs is shifted to extreme market movements, and thus, the hedging motive for the issuer decreases. Payouts for ITM discount certificates and put warrants increase linearly with the underlying. Consequently, issuers still have incentives to hedge their risk exposure, but this incentive is expected to be lower than for ATM certificates, as the changes follow a linear pattern except for extreme movements. Moreover, we expect the incentives to hedge the risk exposure to decrease if the discount certificate is far ITM. In this case, the payouts of the matching put would be very large, and thus, the issuer might have little incentive to issue this put. Finally, for reasonably deep OTM discount certificates, payouts only alter given extreme changes in the underlying. Consequently, the incentives to exploit the complementary payout structures of put warrants and discount certificates first increase and then decrease in the moneyness of the discount certificate until they are nearly nonexistent. To determine whether such nonlinearity appears in our data, we evaluate the model from Column 5 for different values of *MONEY*. The top-left graph in Figure 2 confirms our reasoning.

We also expect that discount certificates' moneyness has an interaction effect with discount certificates' demand. Therefore, we modify the model given in Column 5 of Table 7 by adding an interaction term between the dummy variable for being traded and the squared term of moneyness. We evaluate the model for different values of moneyness, once for traded certificates and once for nontraded certificates. In the top-right graph of Figure 2, we

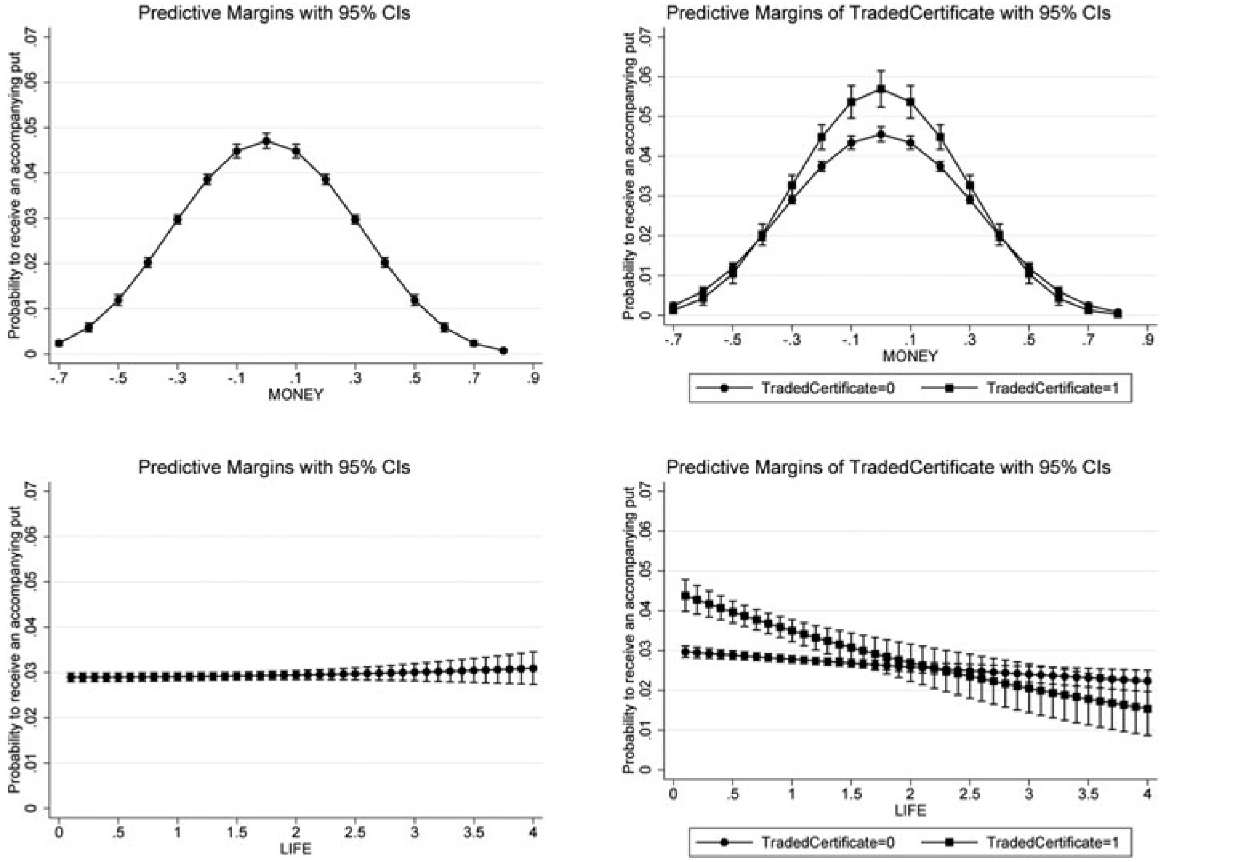

FIGURE 2 Nonlinear effects of moneyness and time to maturity. *Note*. All the results shown are modifications of the model presented in Table 7. The upper-left graph comes from a model in which we replace $MONEY$ by $MONEY^2$. The upper-right graph comes from a model in which we replace $MONEY$ by $MONEY^2$ and $MONEY^2 \times D\_SHARES_{t-1}$. The model is then evaluated separately for traded and nontraded discount certificates. The lower-left graph comes from a model in which we replace TtM by TtM^2. The lower-right graph comes from a model to which we add $TtM \times D\_SHARES_{t-1}$. The model is then evaluated separately for traded and nontraded discount certificates. CI: confidence interval

find that traded and nontraded discount certificates do not differ from one another when they are either deep ITM or OTM. However, traded discount certificates close to the money have a significantly higher probability of receiving a matching put than nontraded certificates. Thus, ATM discount certificates are the most likely to receive a matching put. Note that this argument differs from demand-related arguments, as ITM discount certificates are the most attractive for retail investors and face the highest demand. As puts matching OTM discount certificates are also OTM, these puts offer investors cheap insurance against extreme market movements. Consequently, we expect high demand for this type of put (Bollen & Whaley, 2004; Gârleanu et al., 2009).

The lower panel in Figure 2 depicts nonlinear effects of discount certificates' time to maturity. The left graph shows that using the squared term of time to maturity does not substantially affect the probability of receiving a matching put. We expect issuers to have greater incentives to issue a matching put when the time to maturity of the demanded discount certificate is short than when it is long. There are several reasons for this expectation. First, warrants are issued as American style, whereas discount certificates are European style. Thus, issuing and selling put warrants with long time to maturity does not necessarily imply having this position at the maturity of the discount certificate. Second, retail investors may not necessarily hold their products until maturity. Instead, they may sell a discount certificate long before the product's maturity date. Therefore, issuers have greater incentives to use natural hedging strategies when the products come closer to maturity. As we do not find nonlinear effects in the time to maturity (see the lower-left graph of Figure 2), we use the dummy variable equal to 1 when the certificate is traded and interact it with time to maturity.[13] In line with our above argument, we find in the lower-right graph that the probability of receiving a matching put does not

[13]Thus, we consider time to maturity, the dummy variable for being traded and an interaction term between this dummy variable and time to maturity.

differ between traded and nontraded certificates when the time to maturity is longer than 1.25 years. However, when the time to maturity is shorter than 1.25 years, traded discount certificates are significantly more likely to receive a matching put than nontraded certificates.

In unreported regressions, we check whether the positive effect of discount certificates' demand can also be observed in estimations for single issuers. For nine issuers (BNP Paribas, Citigroup, Commerzbank, Deutsche Bank, Dresdner Bank, Goldman Sachs, HSBC, Société Générale, and Vontobel), we have sufficient data with respect to both the number of observations and the number of discount certificates with matching puts. Discount certificates' trades have significantly positive effects on the probability of receiving a matching put for six issuers, whereas, for three, the effect is insignificant. Thus, single-issuer estimations support our findings from the pooled analysis and indicates that some of the issuers in our sample show signs of cross-issuance activity in line with risk management considerations to complement traditional risk management approaches.

4 | CONCLUDING REMARKS

We studied pricing and issuance dependencies between various types of SFPs belonging to the same issuer portfolio. Focusing on products that complement one another to create simple (deterministic) payout profiles for the issuer, our study provides evidence that issuers of SFPs exploit the complementary characteristics of various types of SFPs and engage in cross-pricing. This may be driven by an attempt to manage the risk exposure of their portfolio and complement traditional risk management approaches. Our results indicate that (a) the prices of put warrants that match the characteristics of discount certificates decrease when the discount certificates are purchased in a substantial number. The advantage that issuers gain by exploiting the complementary structure of these products gives them leeway when pricing these products. (b) The margins of SFPs are higher when the issuer has other SFPs outstanding that increase the overall risk exposure of the issuer. (c) Issuers bring complementary products (e.g., put warrants and discount certificates) to market. The probability of a discount certificate receiving a matching put increases as the discount certificate is purchased in the market for the first time.

Our study contributes to the literature on SFPs in several ways and, in a broader context, to the literature on cross-pricing and cross-selling. In contrast to the existing literature, we do not consider single products alone but instead consider combinations and portfolios of SFPs. This allows us to identify one possible risk management approach of SFP issuers and a pricing factor associated with this approach. By simultaneously analyzing multiple products, we provide evidence of cross-pricing in the SFP portfolio. Our paper emphasizes a new perspective on product range choice and coordinated pricing for multiple products. Although the existing literature on cross-selling and cross-pricing focuses on the issue of customer retention, our results indicate that coordinated product range decisions and pricing may not only be used to retain customers but also to benefit the supplier of products in aspects other than simple sales—namely risk management.

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APPENDIX A: BRIEF INTRODUCTION TO STRUCTURED FINANCIAL PRODUCTS

Issuers' future payouts from issuing SFPs are uncertain. In contrast to simple financial products, such as stocks, future payouts follow a nonlinear relationship with points of discontinuity. To illustrate this point, consider Figure A1, which shows the payoff profiles of a put warrant, a call warrant, a discount certificate, and a bonus certificate. We focus on the first three types of SFPs, as these were most widely issued and traded during our study period. Bonus certificates play a minor role, but they are the next relevant product type.

Put and call warrants are in many ways similar to put and call options, but a few key differences distinguish them. In contrast to put and call options, the purchase of warrants is associated with fewer requirements, such as margin calls, whereas warrants also allow investors to obtain a fraction of one unit of the underlying. In Germany, put and call options written on various underlyings are traded with margin calls on EUREX. An investment in warrants and other SFPs exposes retail investors to the credit risk of the issuer, irrespective of whether retail investors buy the SFP OTC or in secondary markets, because the European Warrant Exchange of the Stuttgart Stock Exchange and Certificate Stock Exchange, which belongs to the Deutsche Boerse AG, do not utilize margin accounts. In contrast to plain vanilla options, warrants do not allow short positions, and the provision of liquidity is restricted to a market maker, which is, in most cases, the issuing entity.

Discount certificates allow an investor to purchase an entire market index or individual stock at a discount that may be far below the current value of the underlying. At maturity, the investor receives the underlying according to the subscription ratio of the certificate if the value of the underlying is smaller than a so-called *CAP*. However, if the value of the underlying is larger than the *CAP*, the investor receives a cash amount according to the *CAP*. OTM discount certificates, the *CAP* of which is lower than the value of the underlying, are similar to a bond. Whenever the underlying falls under the *CAP* of the certificate, that is, the certificate reaches the money, the *bond* partly defaults, that is, the buyer of the certificate receives less than the *CAP*. In a similar context, Henderson and Pearson (2011) show for the case of Stock Participation Accreting Redemption Quarterly-Pay Securities issued by Morgan Stanley that the expected return of such certificates is less than the riskless rate and even negative. For the case of ITM discount certificates, by contrast, the investor can participate in the appreciation of the underlying. Thus, ITM discount certificates are similar to stocks. However, the initial investment for ITM discount certificates is low, by comparison.

Bonus certificates incorporate a guarantee that the investor will receive a specified payout (the *bonus level*) if the underlying does not reach or fall below an established price level (the *knock-out barrier*) during the term. Possible profits from the bonus certificate are not limited if the instrument rises above the strike. If the safety threshold is breached, the bonus certificate essentially becomes an index certificate. After a breach of the safety threshold, payouts of the bonus certificate 1:1 reflect the underlying. The bonus level is no longer guaranteed, even if the underlying rises above the knock-out barrier again during the term.

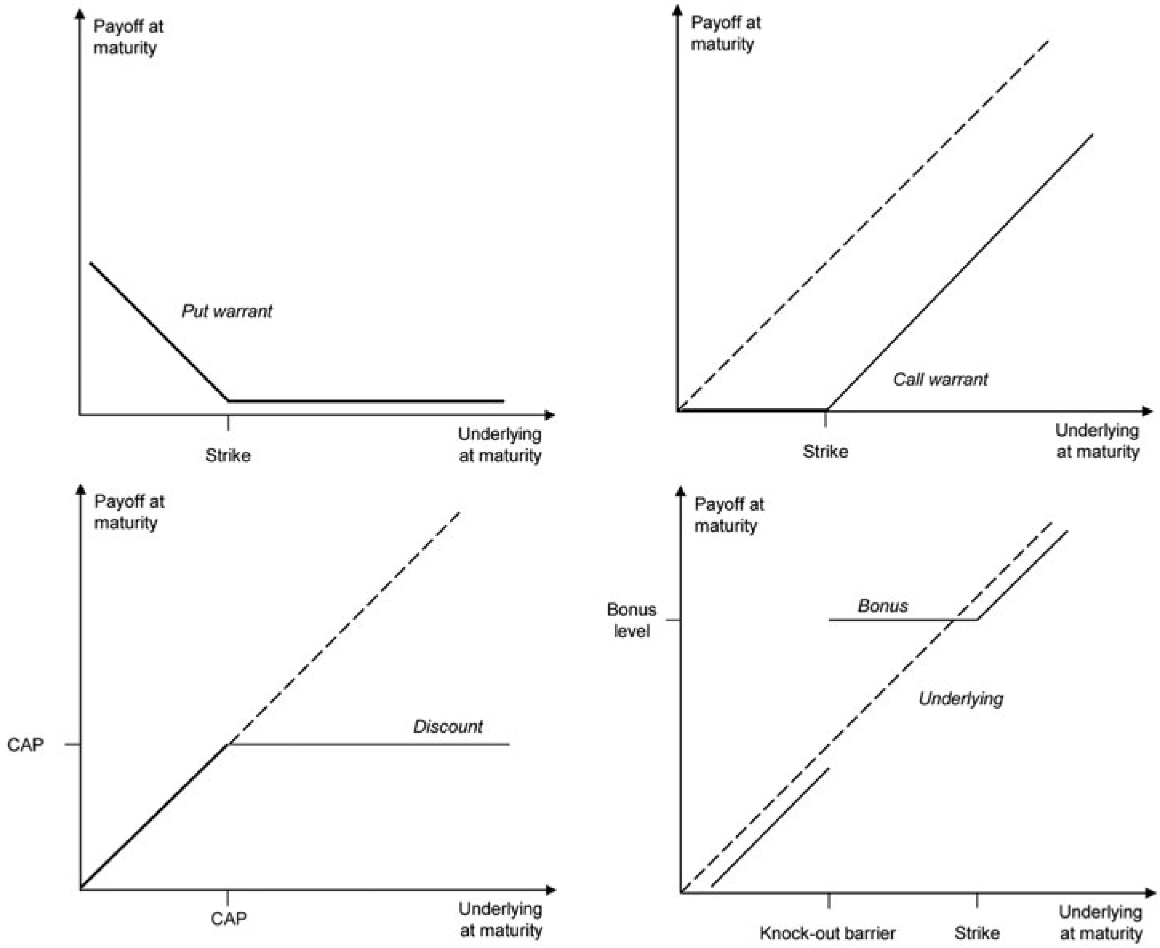

FIGURE A1 Payoff profiles for selected structured financial products. The figure shows the payoff profiles for a put warrant, a call warrant, a discount certificate, and a bonus certificate

APPENDIX B: CALCULATING MARGINS

Margins denote the relative difference between the market price of a product and its TV. Although no costs of structuring, selling, and advertising or additional hedging costs that may arise for deep ITM or OTM products are considered, this margin is called the gross margin:

$$V_t = (P_t - TV_t)/TV_t.$$

Recent studies (e.g., Baule, 2011; Schertler, 2016) often use the model proposed by Hull and White (1995) to determine SFPs' TVs, as this model considers the issuers' credit risk by assuming that it is independent of market risk. The TV of a put warrant is determined using the pricing model by Cox et al. (1979) allowing for early exercise and then discounting the model-implied value with the issuers' credit spread.

The TV of a discount certificate follows by discounting the TV implied by the model proposed by Black and Scholes (1973) with the issuers' credit spread, s

$$TV_t = e^{-s(T-t)} \cdot BS_t,$$

with

$$BS_t = ae^{-r^{FW}(T-\tau)}(S_t N(-d) + CAPe^{-r(\tau-t)})N(d - \sigma_t(\tau - t)^{0.5}),$$
$$d = (\ln(S_t/CAP) + (r + \sigma_t^2/2)(\tau - t))/(\sigma_t(\tau - t)^{0.5}),$$

where t is the day for which the TV of a discount certificate is calculated, T the maturity date, τ the reference date (on which the repayment value of the certificate to the investor is determined), S the price of the underlying, a the subscription ratio that specifies in most cases a fraction of the underlying to which the certificate refers, r the spot rate for $\tau - t$, r^{FW} the implied forward rate for $T - \tau$, and σ the volatility of the underlying.